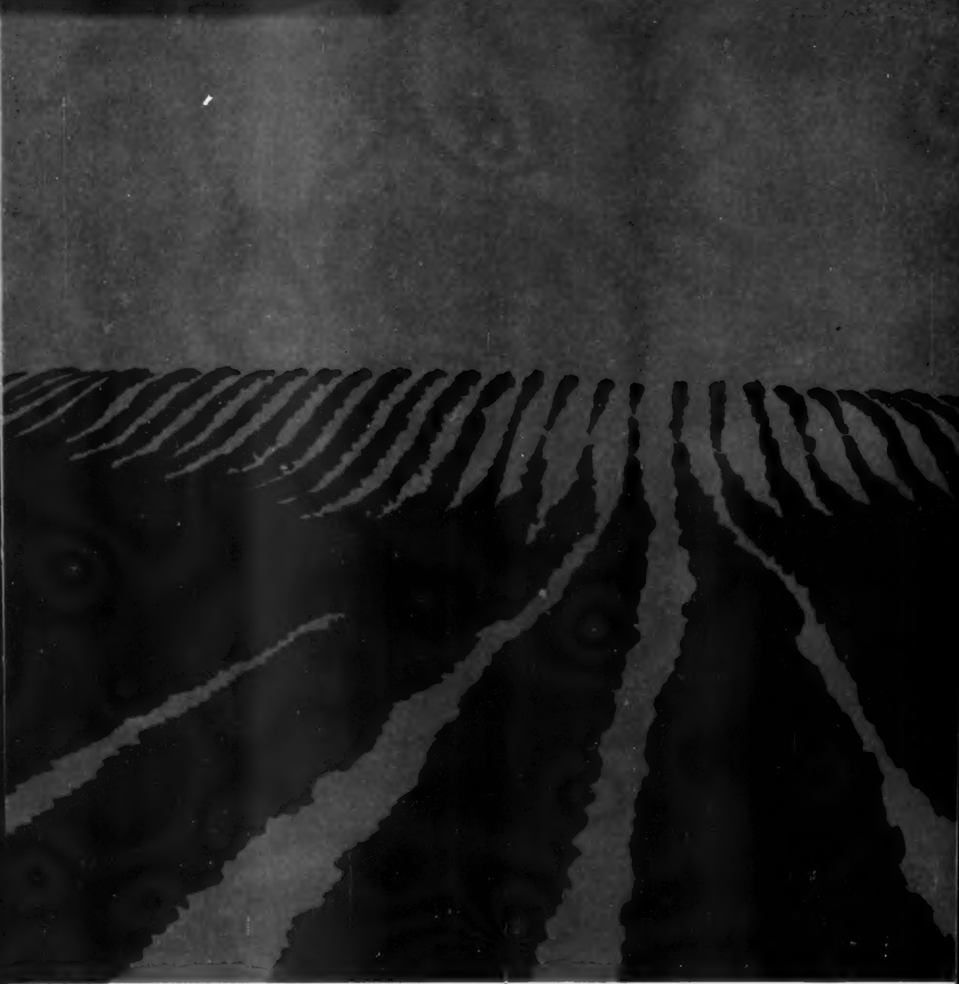

CONTROL OF SOIL EROSION IN NEW YORK

By H. M. Wilson

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NEW YORK STATE COLLEGE OF AGRICULTURE

MECHANICS OF WATER EROSION

Serious losses of soil, plant food, and water can result from the following sequence of events: a hard storm beats down on bare soil; falling raindrops puddle the surface, splash dirt, and partly seal soil pores; the rate at which soil can absorb water decreases; muddy water accumulates then runs off the surface; sheet erosion starts, then rills and small gullies appear; some soil is carried for only a short distance and some is carried off the farm; as rainfall and runoff continue, streams become swollen and bank cutting begins.

When stream bank erosion takes place the bank is undercut at, or below, the water surface. Then the bank collapses and the undercutting is repeated. The problem is most common on stream bends that are exposed to the full force of the current. As cutting progresses and the stream becomes more crooked, water strikes the banks with more force. Eventually the stream develops enough meander to reduce the gradient and the velocity, and cutting slows down. By this time, however, valuable valley land may be so cut up that it is almost useless.

MECHANICS OF WIND EROSION

Conditions that encourage wind erosion are sandy loam or muck soil, lack of vegetation, and strong winds. Although sand grains one thirty-second of an inch in diameter may be pushed along the surface, most of the soil transported by wind is rather fine in texture. The coarser fragments move in a series of short bounces, and after being pushed along the surface for a short distance, leap straight up in the air. At the top of the leap, wind pressure carries the particle along but then it falls almost straight down. The vertical rise and fall occur because the particles are spinning rapidly or because of collision with other particles. Upon striking the ground they usually rebound and repeat the process.

Soil particles that are bounced along seldom rise more than a few feet in the air or move very far from the eroding area. By way of contrast, the very fine dust may rise so high that it forms dust clouds and is carried for long distances.

An important feature of wind erosion is that, on the windward side of an eroding field, the movement of soil is zero. From this point the amount of soil moved increases progressively to the limits prescribed by wind conditions until an obstruction is encountered. If wind erosion is not controlled at its source, it may get out of hand entirely.

CONTROL OF SOIL EROSION IN NEW YORK

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Because erosion control is one of a group of related problems, many of the treatments discussed in this bulletin are desirable in places where erosion is not serious. Because sheet erosion and rill erosion are responsible for most of the soil losses in New York, most of the bulletin is devoted to these problems. There are, however, brief discussions of gully, stream channel, shoreline, and wind erosion. Although they deal with farm land, the principles involved apply to residential property, industrial sites, and highway rights-of-way.

Figure 1. Collecting and measuring devices such as these are used to determine how different soil treatments affect erosion and water losses.

Figure 1 shows equipment for measuring soil and water losses at the Agricultural Research Experimental Station at Marcellus, New York. This is a cooperative project of the Agricultural Research Service of the United States Department of Agriculture and the Cornell University Agricultural Experiment Station. It was at such New York locations that the information cited in this bulletin was obtained.

EROSION AND WHAT IT DOES

The word erode comes from the Latin word *erodere* meaning to gnaw out. As applied to soil it usually refers to the process whereby particles are dislodged and transported by water or wind.

Soil erosion may be a swift destructive force, a steady drain on soil resources, or a slow, nearly harmless process. In some countries of the world it has caused the decline and destruction of great civilizations. In parts of the United States, huge gullies and dust storms have ruined what was once good farm land. Few land owners have been put out of business by erosion in New York, but it has prevented many from enjoying the full fruits of their labor.

Crop yields are lowered

For the past 17 years, average crop yields have been 28 percent smaller from well fertilized plots where moderate erosion has been permitted than from adjacent plots where erosion has been controlled. Crops grown in this experiment have included corn, tomatoes, cabbage, beans, grain, and one year of hay. The soil is Honeoye silt loam, one of the best in the State. For the first five years of the experiment there was little difference in yields from the two areas, probably because both had suffered moderate erosion in the past and a building-up period was required before erosion control could show benefits.

Plant food is wasted

Soil carried from a field by water contained five times as much organic matter, three times as much phosphorus and one and one-half times as much potash as did the soil that remained in the field. Moderate erosion may remove more plant food in a year than is used by the crop.

The better parts of the soil are removed

Soils consist of particles ranging in size from coarse to fine. The larger fragments and stones are inert materials that have little value; the smaller particles, such as those that will pass through a screen with 25 holes to the inch, are the ones that store plant food and moisture. When erosion takes place as illustrated by figure 2, it is the finer and more fertile particles that are carried away.

Figure 2. Erosion washes the finer and more fertile soil particles from the field and may deposit it along fences and hedgerows.

Water runoff is increased

Fast growing crops need more water than is supplied by normal rainfall and, unless they are irrigated, must depend on water stored in the soil. Erosion depletes a soil's water storage capacity. For example over a four year period there was three times as much runoff from eroded plots as from check plots where erosion was controlled. The runoff from the eroded plots represented one-third of the total precipitation; from the non-eroded areas it was less than one-tenth.

Eroded soils are harder to handle

Good surface soil is friable, easy to work and permits ready movement of water. When part of the topsoil is removed by erosion, subsoil becomes mixed with the furrow slice. Because subsoil usually has less desirable structure, seed bed preparation is more difficult, water soaks in more slowly, and drainage is impaired.

Ditches and stream channels are clogged

Silting in of channels is such a common occurence that no explanation seems necessary.

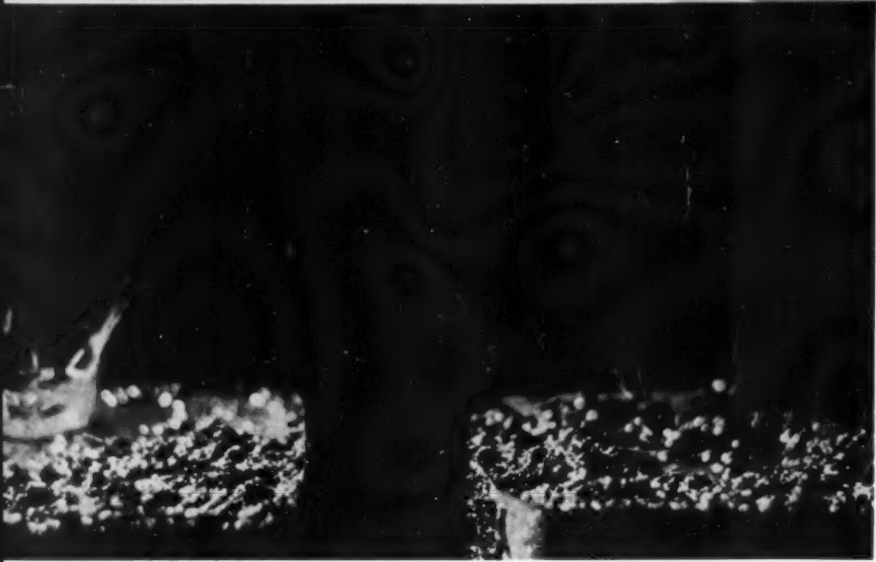

Figure 3. When falling raindrops churn dirt into suspension, the rate at which soil can absorb water is decreased and more erosion occurs.

CAUSE AND CONTROL OF SOIL AND WATER LOSSES

Variables that influence the seriousness of water erosion include the amount, rate and time of precipitation; soil cover; soil characteristics and topography; crop rotation; tillage methods; and the extent to which erosion control methods are used. Although these six variables will be discussed separately, a combination of erosion control measures is usually required.

Amount, rate and time of precipitation

Figure 3 shows that when a fast falling raindrop strikes bare soil the effect is like that of a small bomb. Soil and muddy water are splashed in all directions, soil pores are partly sealed, and soil structure is broken down. This explains why few New York soils can absorb more than one-half inch of rain in an hour. On many soils the absorption rate is much slower. Therefore runoff and erosion are likely on vulnerable land whenever the kind of storm occurs that is classified by the Weather Bureau as excessive.[1] We have more of these excessive storms than we want. During an eight year period 135 of them were recorded at four New York meteorological stations and, of these, 129 came as thunderstorms

[1]Rain in excess of 3.0 inches per hour for five minutes, 1.4 inches per hour for fifteen minutes, 1.0 inch per hour for thirty minutes or 0.8 inch per hour for one hour is classified as excessive.

during June, July and August. This is why our most serious runoff and erosion losses usually take place in midsummer.

Early Spring, when snow is melting, is another period of probable runoff. Conditions under which damage is most likely are frozen subsoil, melted surface soil, deep snow, warm rain, and high temperature. Although quick snow melt is not as common as hard summer rains, it has caused much erosion and many floods. It is less likely to occur in the higher plateau regions where the Spring temperature is usually cool and snow melts rather slowly than at lower elevations.

Until man learns to control weather, he cannot prevent excessive storms or quick runoff. But if he remembers that any locality is likely to be visited by four excessive storms each year, it may stimulate him to establish needed protective measures.

Soil cover and cropping system

To appreciate the value of soil cover we have only to look at history. When New York was covered with forests, erosion was slight and topsoil was formed faster than it was removed. When the forests were cut to make way for cities and farms, this trend was reversed in a very short time. To test the rate at which the transition from soil building to soil erosion took place, a sloping hillside with deep, well-drained soil was cleared and planted to annual crops for several years. At first the high humus, well-granulated soil absorbed water so readily that there was little runoff or erosion. But at the end of three years erosion was as severe on the newly cleared land as on land that had been farmed for generations.

While forests with their canopy of branches and mantle of leaves afford the best soil protection, good sod is nearly as effective. To illustrate, steeply sloping land protected by sod lost only one and one-half tons of soil per acre in four years. During this same period, bare soil lost 270 tons per acre. At this rate all of the plow layer would have been lost from the bare plots had the experiment been continued another eight years. By way of contrast, more than 7000 years would have been required to remove all of the topsoil from the sod plots, and because topsoil is formed faster than that, removal of soil would never be a matter of concern.

All land need not be sod, however, because under favorable conditions, erosion losses are greatly reduced by a remarkably thin cover. When land is plowed an attempt should be made to produce thrifty, fast growing crops that will provide a canopy in minimum time. Even clean tilled crops such as corn afford considerable protection if properly fertilized and grown on adapted soils.

Winter cover crops are another means of providing an umbrella for the soil. No evidence of erosion is visible on the land at the right in figure 4. This

Figure 4. Land on the right is protected by a cover crop and shows no damage, but bare soil on the left is severely eroded.

land was protected by a cover crop, but the bare soil at the left shows considerable damage. Cover crops are particularly helpful if row crops are grown for several years in succession.

Litter or trash on the soil surface is another erosion control device. It helps dissipate the energy of falling raindrops, slows down surface runoff, and permits more water to soak in. In one series of tests, buckwheat straw at a rate of less than one-half ton per acre, reduced the losses of soil to less than one-fourth of the losses where the straw was plowed under. Any material such as straw, manure, sawdust or wood chips may be used. Thick mulches that will contol weeds also are desirable but, except for small areas, sufficient material is seldom available.

Soil characteristics

Erosion is least troublesome on deep, well-drained, friable, gravelly loam soils. These seldom crust or become puddled by falling raindrops, and both the topsoil and subsoil will absorb water readily. So there is less runoff to cause erosion. (see figure 5).

Erosion is most severe on shallow, poorly drained, hardpan soils with silty loam or silty clay loam texture. These have limited water holding capacity, soil

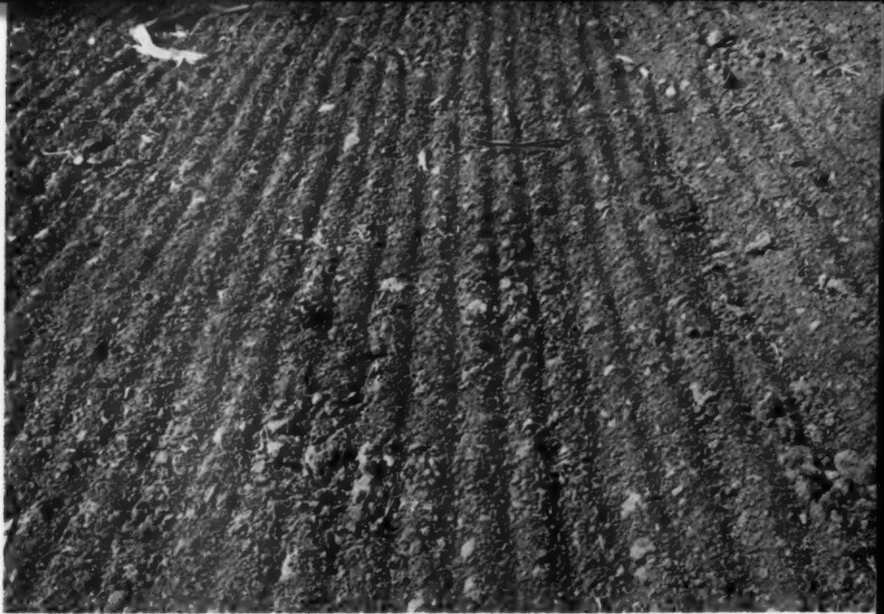

Figure 5. Friable, well-managed soil has a granular crumb structure that absorbs water readily.

Figure 6. Poor soils have low water holding capacity and fine textured soils absorb water so slowly that runoff and erosion are likely to occur.

structure is hard to maintain, and pore sealing is common. The topsoil absorbs water slowly and subsoil is nearly impermeable. Figure 6 illustrates soil condition where erosion is likely to be severe.

Most soils rate somewhere between the extremes that have been cited. For a more detailed description of soil characteristics and how they are recognized, see Cornell Extension Bulletin 904, *Land Judging in New York*.

Steepness and length of slope

Slope is usually measured in percent; that is, the number of feet of elevation in 100 feet of horizontal distance. Other things being equal, the rate of erosion losses increases sharply as the steepness of a slope increases. In one six months period under similar conditions, a gentle (5 percent) slope lost 0.3 ton of soil per acre; a moderate (9 percent) slope lost 1.0 ton and a strong (17 percent) slope lost 14.8 tons.

On long slopes, runoff water from upper areas may collect and add to the problem on lower lying fields. Hence long slopes usually suffer more erosion than shorter ones. Fine soil particles from the slopes settle out in low, flat spots to clog the soil pores and create, or increase the size of, wet spots.

Crop rotations

Slope and soil conditions influence erosion hazards to such an extent that an adapted crop rotation is the foundation for most control programs. A crop rotation is the growing of different crops in the same field in a more or less definite sequence. Except in a few special situations most New York rotations include sod, grain, and row crops. Soil structure improves and organic matter builds up when the land is in sod. When it is plowed, nutrients stored in the organic matter are released. This alternate build-up and release is beneficial and usually results in higher yields of all crops. However, it is seldom necessary or advisable to follow the same rotation on all fields. If modern soil and crop management are practiced, a suitable cropping system for a given field may be any combination from continuous corn to continuous sod.

Figure 7 illustrates a good cropping system wherein row crops are grown on the flattest field, and steep areas are in pasture, long term hay, or woods. Fields in between are in sod about half the time.

Tillage methods

The first and most important tillage is good plowing. On moderate to strongly sloping land, or highly erodible soil, plowing should usually be done in the Spring so that ground will not lay bare over winter. When a moldboard plow is properly adjusted and operated, a limited amount of fitting will prepare an adequate seed bed. The actual amount of preparation depends on the crop.

Figure 7. Flat fields with good soil may be farmed intensively but sloping fields need to be in close-growing crops at least part of the time.

Mellow, well-plowed land for field corn needs little or no fitting if the soil adjacent to the seed is firmed. (For further details see Cornell Extension Bulletin 1031 *The Plow-Plant Method of Corn Culture.*) By way of contrast, small grass and legume seeds need a smooth, well-granulated seed bed to prevent them from being buried too deeply. Again excessive fitting is not required if the soil has good tilth, has been well plowed, and is not dry and baked.

People who fit land too much leave a compact seed bed with soil crumbs ground into a powder. The rate at which land can absorb water is slow and becomes even slower as crusting develops. Rain water that cannot soak in runs off the surface to cause erosion.

Soil worked too wet becomes so packed that it is nearly waterproofed. For best results till soils only as much as necessary, keep off land when it is wet, and maintain a reasonable level of organic matter.

EROSION CONTROL MEASURES

Contour tillage

Contour tillage consists of working land across the slope and as nearly on the level as practical in order that the furrows and ridges left by tillage act as small dams and slow the rapid runoff of water. On erodible soils, contour tillage by itself is effective only on gentle or very short slopes.

Figure 8. Strips of sod between strips of clean tilled crops reduce erosion losses.

Figure 9. A diversion terrace is an eave trough across a slope. It intercepts runoff and seepage water.

Contour strip cropping

Strip Cropping is a compromise between plowing a field and leaving it in sod. As shown in figure 8, it consists of plowing alternate strips and leaving intervening strips in sod until the plowed strips are reseeded. It is adapted to most crop rotation and is effective in reducing soil and water losses. For more information on this practice see Cornell Extension Bulletin 800, *Contour Strip Cropping*.

Diversion terraces

As illustrated in figure 9, diversion terraces are broad shallow channels that intercept and divert excess runoff water into a safe outlet. This serves to divide long slopes into small drainage areas where only small concentrations of runoff water need to be handled at one time. More information is given in Cornell Extension Bulletin 808, *Diversion Terraces*.

Sod waterways

Maintaining or establishing sod in drainage ways, where water concentrates, may prevent gullying. If the waterway does not have the desired cross section, it should be shaped with a plow or grader before seeding. After a sod is established, tillage implements are raised in crossing the waterways to avoid tearing up the vegetation. If the area tends to become wet and waterlogged, a tile line extending the length of the waterway may be desirable.

Gully control

When a gully is formed the damage is done and treatments will not bring back the lost soil. However, some treatment and management will reduce further soil loss. A common method is to divert water from the watershed above the gully to a safe disposal area by a diversion or header ditch. Then slope the sides of the gully with a bulldozer, grader or plow. Next lime, fertilize and seed the area. A light mulch fastened down with chicken wire or mesh will help keep dirt in place while sod is being established. Should a hard rain occur in the meantime, the entire process may have to be repeated.

Stone, wire and log check dams that were once widely used for gully control are now seldom recommended.

Stream bank erosion control

Stream bank erosion is most effectively controlled by placing large rocks at the toe, then sloping and riprapping the banks. This requires heavy equipment, however, and costs more than most individuals can afford.

Preventive treatments are to avoid plowing too close, to keep cattle off the banks, and to plant shrubs. If a tree falls into the channel, it should be re-

Figure 10. Trees fastened together with cables and anchored to the bank help prevent stream erosion.

moved immediately or the current may be diverted into the bank. Brush, stone, piling, or gravel-filled barrels may stabilize small breakthroughs.

For longer trouble-zones, shingling the bank with large trees as shown in figure 10 will provide temporary protection on small to medium size streams. For this method, the first tree is hauled along the bank with the branches upstream. A second tree is placed so that it overlaps about one-third of the first. A five-eights inch or larger steel cable is wrapped around the two trees and clamped. The process is repeated with more trees clamped together until the desired length structure has been assembled. Then the entire barricade is pushed over the bank with a bulldozer. (It pushes very easily). The final step is to anchor the tree barricade with cables attached to "dead-men" buried about thirty feet from the bank.[2]

Trees or shrubs planted behind the barricade may grow enough to protect the banks by the time the anchored trees have rotted.

Shoreline and wave erosion

If shoreline erosion is minor, some of the treatments described under stream bank erosion may be effective. But a person whose property is exposed to the full fury of wind and waves from a large lake or ocean will usually need to obtain engineering advice and either group action or public assistance.

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[2]If more information is desired, write to the Department of Agricultural Engineering, Cornell University, Ithaca, New York, and ask for Mimeo 413 *Flood Control and Streambank Stabilization for Agricultural Lands*.

Wind erosion

Emergency relief from wind erosion is provided by plowing furrows at right angles to the wind, roughing the surface, or using a field cultivator to bring up lumps. If the area is small and an irrigation system is available, wetting the surface will be effective. In the western states wind stripcropping, consisting of alternate strips of grain and fallow, is a familiar sight. This system may warrant consideration in some of New York's vegetable producing areas.

Temporary windbreaks of snow fence or cornstalks provide surprising protection to tender plants growing on the lee side. Trees and shrubs, usually Basket Willow or Amur River Privot, are used on some New York muck areas.

Multiplying the height of a windbreak in feet by 10 indicates the approximate number of feet that it will reduce wind movement to safe velocities. Sod, winter cover crops, and crop residues are effective and should be used to the fullest possible extent.

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